A Mechanical Engineer's Perspective on Tent Foaming:

Avoiding the Unintended Consequences of Good Intentions

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As you have read in the accompanying article, foaming tents achieves reductions in electrical demand and consumption which can translate into fuel savings. However, if improperly applied, unintended consequences can offset the expected benefits.

The purpose of this article is to discuss those unintended consequences and how they can be mitigated so that the full savings potential of foaming tents in the Southwest Asia area of responsibility (AOR) can be realized. More complete guidance is contained in Air Force ETL 10-6, *External Foam Insulation of Temporary Structures*.

Tent foaming involves spraying up to 2 inches of foam over the exterior surface, reducing the heat transfer through the tent's walls and roof by up to a factor of four. With such a significant reduction it's tempting to just forge ahead, but before you do, let's consider some of the possible side effects and unintended consequences. Are they beneficial or will they spoil our chances of success? What will be the effects upon related systems?

Tents' HVAC Systems

Currently our tents are equipped with a field deployable environmental control unit (FDECU) capable of providing 5 tons (60,000 BTU/hr) of cooling. These units have been sized to satisfy the expected cooling loads of the tents in the extreme environment of the AOR. The sensible and latent loads resulting from the heat gain from walls and roof, conditioning of outside air (ventilation and infiltration), occupants, and plug-in loads (lights, small appliances) are all taken into account in determining total cooling load. Sensible loads affect the temperature of the space and result from the conductive heat gain, cooling of outside air, heat from lights, appliances, and the human body. On the other hand, latent loads are determined by the amount of moisture removed from the outside air and in the space to achieve a desired level of relative humidity (RH).

The FDECU senses only temperature in the space (sensible load) and not the RH (latent load). When the thermostat in the tent calls for cooling, it cycles the FDECU compressor on and activates the cooling coil. The supply air fan runs continuously, providing for ventilation and circulation of air in the tent. Moisture is removed from the air only when the coil is activated, with the amount of moisture removed dependent on the run time of the compressor, the characteristics of the cooling coil, and the psychrometric conditions of the air. In summary, the longer the coil remains activated, the more moisture it can remove and the lower RH in the space.

In hot and humid climates, insulating the tent will reduce the conductive heat gain through the walls and roof by a factor of four, total sensible load will be reduced by 50%, and total load by almost 40%. This will result in the FDECU being considerably oversized, which affects the system's ability to remove moisture in two ways. First, space temperature is quickly satisfied, causing the cooling coil to shut off and dehumidification to cease; the decrease in total operating time of the cooling coil reduces the time available for moisture removal. Secondly, the supply air fan continues to operate while the cooling coil is shut off, resulting in ventilation air not being dehumidified and essentially pumping moisture back into the tent. Changing the sensible heat gain into the tent has significant impact on the sensible heat ratio of the space and the capabilities of the HVAC system to remove moisture.

Consequences

Degradation of the indoor environment: Space humidity levels will exceed recommended levels for extended periods. High humidity levels increase the possibility of mold and mildew growth resulting in a damp and musty environment and decreased indoor air quality. Controlling humidity is also critical in achieving occupant comfort. Generally, people are more comfortable at a higher temperature and lower RH level than at a lower temperature and high RH level. When humidity levels are excessive, occupants are known to drive the thermostats lower in a quest for comfort. The result is over-cooling of the space, which actually increases RH and the damp and clammy feeling in the tent. When interior temperatures are pushed below the outdoor dewpoint temperature, the chances of mold and mildew are greatly increased. This is a result of unconditioned outside air condensing on cold interior surfaces when doors are opened or ventilation air is introduced.

Short cycling of the FDECU: When the FDECU is oversized, it will quickly satisfy the load and shut off the compressor. However, since the supply air fan operates continuously to meet the ventilation needs of the occupants, interior temperatures rise quickly, cycling the unit back on. The resulting short cycling of the compressor and condenser fan reduces their operating life.

Electrical System Impacts: Air conditioning of the tents represents the largest load on the electrical generation and distribution system. Upon start-up, the FDECU in-rush current spikes at almost three times its running amps. This can be a peak of almost 80 amps. By reducing run times, cycling of the compressor will occur more frequently. Considering there are hundreds of FDECUs connected to the base grid, increasing the number of start-ups will raise the probability of multiple starts occurring simultaneously. Without sufficient spinning reserve to handle this momentary increase in load, low voltages and system instability can result.

Solutions

Avoiding these possible consequences in the AOR is simple. All the problems discussed stem from oversized HVAC equipment. By taking into consideration the overall effects of the new load and taking simple steps to match equipment capacity to it, these issues are avoided. By combining air conditioning loads by reconfiguring the flex ducts so that one FDECU serves two tents, equipment capacity is better matched to the load. It also significantly reduces the number of FDECUs needed in the AOR, which pays additional dividends in reduced maintenance, logistic support, and electrical demand.

Enabling one unit to serve two tents requires the addition of tees in the supply and return flex ducts as shown in the Figure (Figure 2 from ETL 10-6). Use of locking dampers in the tees to balance air flows is recommended to allow for variances in duct pressure drops and loads between tents.

The use of an energy recovery ventilator (ERV) is also recommended. Such units can transfer up to 50% of the sensible and latent loads from the exhaust air for preconditioning the outside air required for ventilation. Ventilation air is preconditioned when it's drawn through the ERV by the negative air pressure in the FDECU return air duct. Enthalpy exchange takes place with the supply air from the FDECU (which is under positive pressure) as it's exhausted through the ERV. This configuration eliminates the need for fans in the ERV making it a passive device. Note that the air discharged from the ERV is cooler than ambient and by releasing it in front of the condenser coils, additional energy savings can be obtained.

Because the FDECU serves two tents, ventilation rates must be doubled. This also doubles the ventilation latent load and decreases the sensible heat ratio of the return air stream, reducing the coil's moisture removal capacity. However, by installing the ERV, the sensible heat ratio will in essence remain unchanged.

Conclusion

Applying foam insulation to tents in the AOR presents real opportunities to save energy and significantly reduce logistical support. Avoid unintended consequences; follow the recommendations in ETL 10-6. It's your flight plan to success.

Mr. Hart is the Air Force subject matter expert for HVAC, HQ AFCESA, Tyndall AFB, Fla.

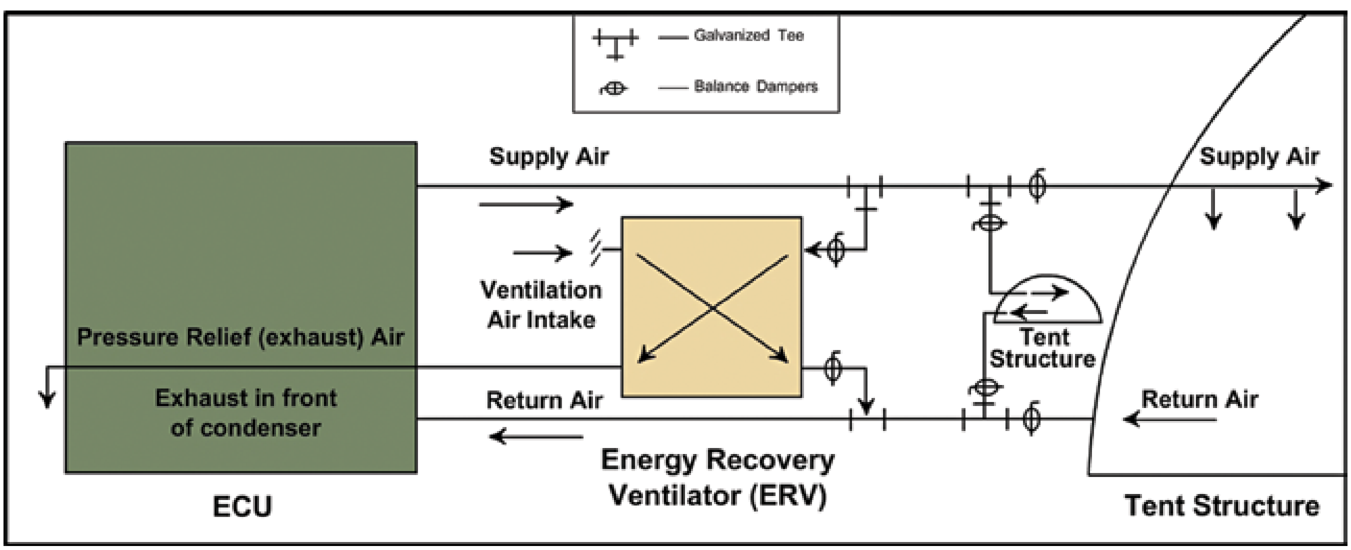

Figure. Diagram for connecting 1 FDECU to 2 insulated tents. (Figure 2 from ETL 10-6)

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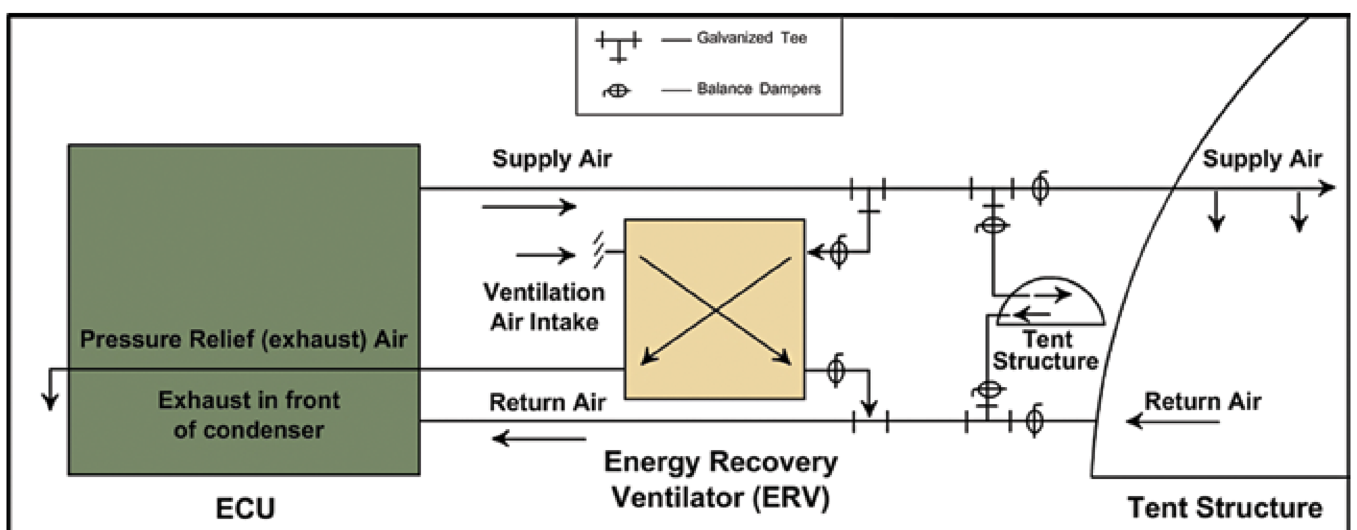

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Future of Airfield Damage Assessment

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A top priority following an enemy attack is expeditiously recovering the airfield. Presently, airfield damage assessment teams, on foot or in vehicles, survey the damage and prioritize repairs — a lengthy procedure that may also expose team members to a hostile environment.

In 2008, a Joint service program called CRATR (Critical Runway AssessmenT and Repair) was launched to modernize airfield recovery by investigating solutions in technology; material; and tactics, techniques, and procedures. Thus far, CRATR has focused on two phases of recovery: damage assessment and crater repair.

The Rapid Airfield Damage Assessment System (RADAS) is an effort to help prioritize repairs by rapidly selecting the best minimum airfield operating surface (MAOS). Development engineers are turning to continuous advances in remote sensing technology such as unmanned systems, sensors, image processing algorithms, and geographic information systems (GIS) to equip the RADAS.

RADAS design faces some challenges: surveying a large surface area with high resolution to detect small targets; adequate mapping accuracy; and capability in a variety of environmental conditions. It must be user-friendly, small and economical enough to equip many bases, and reliable for use in contingencies. Finally, RADAS must perform its end-to-end assessment with MAOS selection within 30 minutes.

The requirements list and rapid technology fielding motivation have shaped the RADAS into a system of systems. Its data acquisition system is a result of the proliferation of unmanned aerial systems in DOD. A small, tactical, runway-independent, remotely piloted aircraft of less than 80 pounds is rapidly launched on a preplanned survey path. Its sensor suite consists of the latest turreted camera system with electro-optical and infrared imagers for day, night, and reduced visibility conditions. Other types of sensors, such as Light Detection and Ranging and Synthetic Aperture Radar are being investigated as their technologies miniaturize and resolution capabilities increase.

RADAS imagery is transmitted in near-real time to its data processing system located in a ground control station. Innovative processes paste captured image frames into a mosaic of the pavement before geographically registering it to a baseline image. Challenges exist to perform accurate georegistration with the narrow field-of-view of the electro-optical or infrared imagery. Novel image-processing algorithms and user interfaces aid extraction of damage items from the image. The objective is for a single operator to view imagery of all pavement areas and declare hundreds of damaged items rapidly and reliably.

Finally, RADAS is leveraging existing Civil Engineering GIS tools (e.g., Geospatial Expeditionary Planning Tool) to expedite and improve MAOS selection. Populating a digital map of the airfield with identified damage items allows an operator to interactively designate the MAOS using least-cost-routing and damage repair time estimation algorithms. A file with coordinates of the MAOS and prioritized damage repairs is then passed on to explosive ordnance disposal and crater repair teams. Before the RADAS can become operational, some bigger items will need to be fully addressed; ownership and manning within different career fields, integration with current airfield operations, supportability, and overall doctrinal changes within recovery operations.

During testing in August 2009 at Avon Park AFR, Fla., the RADAS was able to perform a night-time, end-to-end assessment of more than 110 craters over the entire airfield and produce a MAOS in less than 26 minutes, a considerable improvement over previous results. Testing for the next prototype iteration is scheduled for July 2010.

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Mr. Mike Busutil (left) and Mr. Stephen Dixon from the NAVAIR UAS Deployment Team navigate the RADAS system to rapidly assess airfield damage from their ground control station. (photo by Mr. Oscar Reihsmann)